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DRAWING Nº A.

A SWITCH. *Fig. 1. is the Apparatus placed at* *line arises where a wheel has to pass onto or along a Cross Line as in Switch (Fig. 1) from* c *to* d; *in Crossing Point Fig. 4 from* i *to* k;

A HALF SWITCH. *Fig. 2 is one half of the* *Over Crossing Points (Fig. 5) from* o *to* p.

T *is a fixed Point so placed on the Main Line that the Traffic in its ordinary course meets it and has a tendency to run against it, unless*

sometimes compared with a whole *a Check Rail as explained in Fig. 4. Such Points occur (supposing the Traffic to run in a direction contrary to the Arrows) in Switch*

AN AUTOMATON SWITCH *is detailed and* *in Crossing Point Fig. 4 at* i. *and in Pair of Over Crossing Points Fig. 5. at* n. *In this last Apparatus also there occurs a Meeting Point*

the Traffic runs in the direction of the Arrows. It is therefore an objection to the Over Crossing Points Fig. 5. that one of their Points

A CROSSING POINT. *Fig. 4. is a simple* *ys be a Meeting Point.*

A PAIR OF OVER CROSSING POINT

Pair of Points connected as shown.

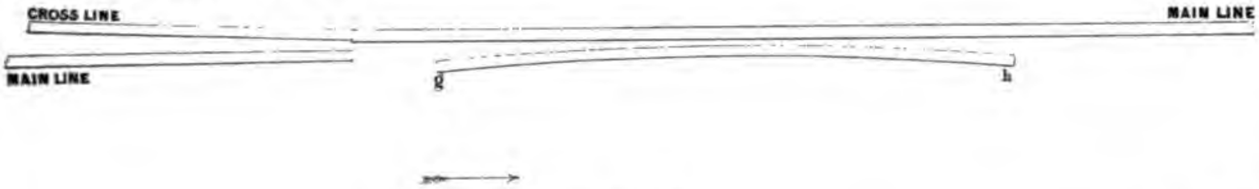
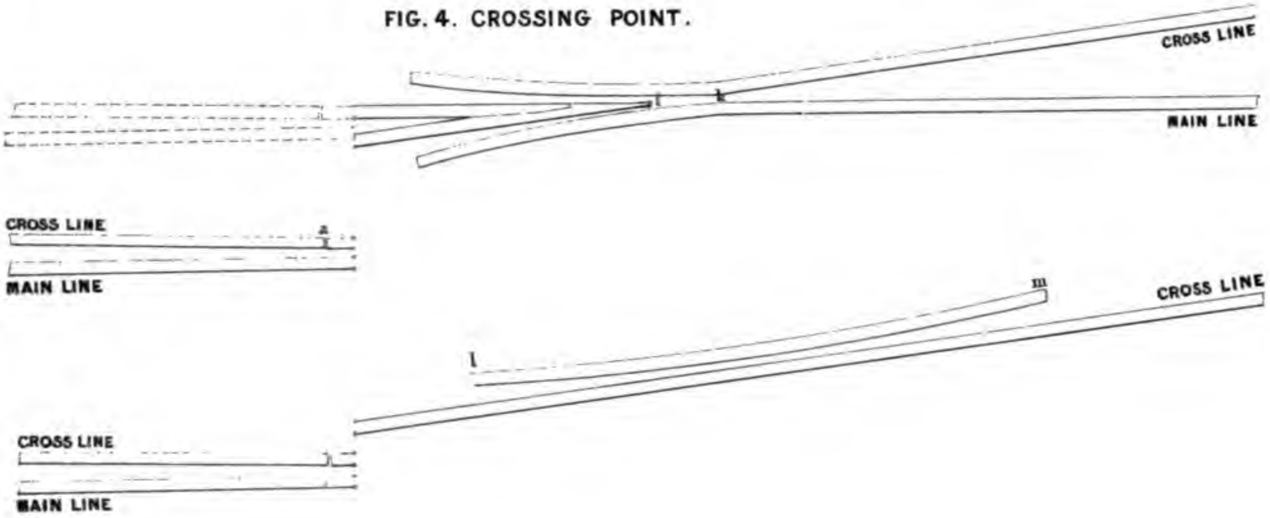
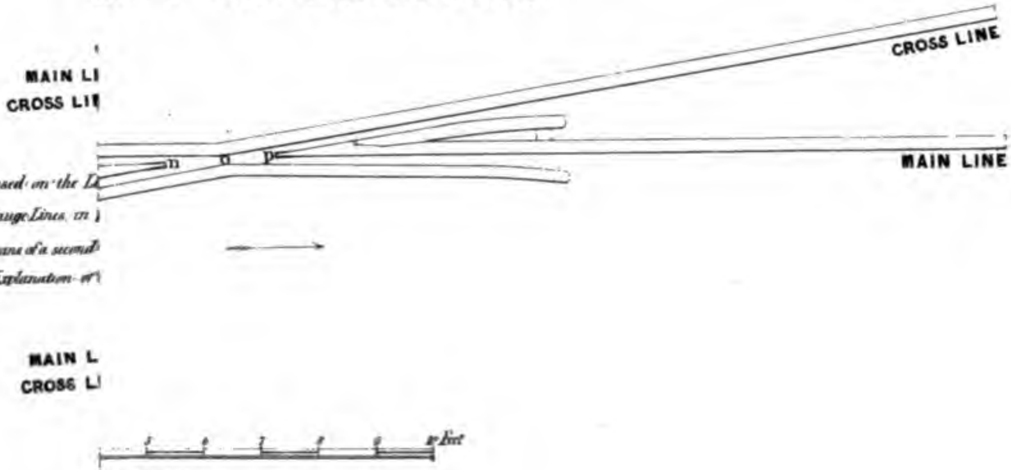


FIG. 4. CROSSING POINT.



AIR OF OVER CROSSING POINTS.

This Switch is used on the
of the Narrow Gauge Lines, in
in Fig. 1. By means of a second
removed. See Explanation of



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[illegible]

THE DOUBLE GAUGE.

OBSERVATIONS

BY

MR. R.obert STEPHENSON

ON

MR. BRUNEL'S REPORT ON THE DOUBLE GAUGE.

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LONDON:
PRINTED BY STEWART AND MURRAY,
OLD BAILEY.

1847.

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The same, with the more important details inserted.

„ 4.—Mr. Brunel's sketch of a crossing for both Gauges conjointly.
The same, with the more important details inserted.

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The same, with the more important details inserted.
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The same, with the more important details inserted.

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As at present;
Under the three-rail Mixed Gauge system, and
Under the four-rail Mixed Gauge system.
[These Drawings, in consequence of their size and complexity, have not been lithographed.]

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As at present laid;
Under the three-rail Mixed Gauge system, and
Under the four-rail Mixed Gauge system.

„ 10.—Drawing of a Broad and Narrow Gauge carriage on a three-rail siding, as proposed by Mr. Brunel, shewing how they will be circumstanced as to buffing and drawing together.

OBSERVATIONS,

&c.

To R. Creed, Esq.,

Secretary to the London and North-Western Railway Company.

24, Great George Street, Westminster,
July 7th, 1847.

Dear Sir,

In compliance with the request contained in your letter of the 17th April, I have considered the Report of Mr. Brunel to the Directors of the Great Western Railway Company, which has been submitted to the Commissioners of Railways, in explanation of the mode in which it is proposed to carry into effect their order, that the Narrow Gauge (as well as the Broad) shall be laid down on the Oxford and Rugby Railway, and also between Worcester and Wolverhampton on the Oxford, Worcester, and Wolverhampton Railway.

From this Report, it appears that Mr. Brunel proposes,—

First. Generally to lay the railways in question with one additional rail for the Narrow Gauge, this being the simplest plan; but, wherever it may be more advantageous, to lay two additional rails.

It appears also that Mr. Brunel prefers to adhere to the longitudinal sleepers used on the Great Western Line, having varied from that system between Cheltenham and Gloucester rather in deference to the views of others than in accordance with his own views.

Secondly. Mr. Brunel proposes either to mix the sidings and crossings for the two Gauges, or to keep them separate. It is not stated which of these Plans is preferred; but the feasibility of either or both, where desirable, is affirmed.

It is difficult to reply to this Report in its present form; for though, under the first heading, the main difficulties as regards the laying of the rails are touched upon, they are not solved, and the Diagrams do not exhibit clearly the complications which arise from the introduction of the second Gauge, being merely rough sketches, and not scale representations of crossings, &c., as actually laid in practice, and, under the second heading, no attempt is made to explain the mode proposed for carrying on the traffic at the Stations.

I have accordingly prepared more detailed developments of the Diagrams* accompanying Mr. Brunel's Report, in order to shew the extent to which the rails are actually affected by the intersections which he exhibits by mere cross lines. I have also added Plans of approved Stations actually executed by Mr. Brunel and myself, composed of various parts, such as the first-mentioned Diagrams exhibit separately. Certain other Drawings are appended, which will be explained in their proper places. To all these Drawings I have preferred to add explanatory notes, rather than to encumber these general remarks with detail, which can only be understood by a careful study of the Plans themselves. I would remark, that, without attention to these notes, it is impossible thoroughly to appreciate the difficulties which are alluded to in these observations.

I now proceed to consider the difficulties attending the introduction of a second Gauge, both in the construction and working of a railway, and the best means of removing them, so far as may be practicable.

I trust that the length to which my remarks will necessarily extend will appear to be justified by the importance of the subject. You will remember not only that the Great Western Railway Company are bound by the requirements of a Parliamentary Committee, and of the Board of Trade, to maintain a Narrow Gauge Railway, with all facilities for working it at the stations and along the line, from Rugby to Oxford; but that they have further pledged themselves to connect Oxford with the Narrow Gauge South-Western chain of railways at Basingstoke, by means of a Narrow Gauge link through Reading.

The establishment of an unbroken connection, by means of a safe and properly constructed Narrow Gauge Railway, between the two great Narrow Gauge systems of railway in the North and South of England, is therefore considered by the legislative authorities a matter of national concern, for otherwise the construction of a duplicate railway ninety miles in length would not be enforced. During the present session, moreover, not only have about one hundred and fifty additional miles of railway been proposed to be laid on the Mixed Gauge system, but various Parliamentary Committees have appeared to consider it important to insert in Railway Bills a clause binding Companies to lay down additional rails for another Gauge, on the Railway Commissioners deciding to exercise powers to order such additional rails.

Since, then, the notion of this untried system of Mixed Gauge, and the reliance upon it as a remedy for the evil of a Break of Gauge, and as a compromise between the conflicting systems of Gauge, seem to be spreading both in Parliament and with the public, I am desirous not to let pass the present opportunity of treating the subject as completely as our present experience permits.

---

* See the accompanying Drawings.

Permanent Way.

In considering the effect of introducing a Mixed Gauge as regards the construction of the permanent way, I omit, for the sake of brevity, all remarks on the mode of laying the additional rail along the main line where it is unbroken by the crossings, sidings, &c. necessary for the carrying on of traffic at stations and other points. The mechanical po[illegible] of laying down an additional or intermediate rail in such parts of the line is ad[illegible] and the expense of laying it down is given in Appendix II.; I am, however, of opinion, that the keeping the road in repair under the three-rail system, even in those parts of the line where there are no intersections of the rails, will be troublesome and expensive, in consequence of the unequal action upon the rails.

Premising this, I proceed to consider the difficulties attending those points of divergence from, and intersection with, the main line which are the necessary accompaniments of every railway serviceable for traffic.

First then, following the order of Mr. Brunel's remarks as to crossings:— My whole experience of railway arrangements leads me to a conclusion very different from Mr. Brunel's, that crossings between the main lines are but rarely necessary. On the London and Birmingham Railway, for instance, a length of one hundred and twelve miles, there are no less than fifty-eight crossings, and on the lines in the north, where the mineral traffic is greater, their number in proportion to the length of the railway is much increased. Indeed, wherever we engage to admit traffic upon a railway, whether at passenger stations or at intermediate points along the line, such a crossing between one main line and the other is necessary; the ordinary process of returning a carriage or waggon from any station cannot be effected without the intervention of such a crossing, and if a station is only on one side of a railway, as is sometimes necessarily the case, say the *up* side, the traffic from such a station may pass *up* without crossing the down line, but cannot pass *down* without crossing the *up* line; so that on this account also a crossing is necessary. In one way or other, then, crossings are necessary wherever traffic arises; from the annexed Plan of the Slough Station (Drawing No. 7)* laid out by Mr. Brunel, it will be seen that at this station only there are two crossings between the main lines.

* This drawing has not, in consequence of its size and complexity, been lithographed.

With reference to the mode of laying a through crossing on the three-rail system, I find, after the most careful attempt to introduce into the crossing the automaton switch (in the manner proposed by Mr. Brunel for uniting the Gauges), that room cannot be found for its efficient working (see Drawings 4 & 4A), it will therefore be necessary to use addional half switches (at A and B Fig. 1, Drawing 4) for this purpose, rendering two switchmen necessary to work a crossing instead of one, and introducing into the Narrow Gauge traffic new chances of accident, arising from any failure of the two men working together.

In stations laid out, as at Slough and Reading, on one side of the line, so that every train entering the station has to meet the switches, the risks attending these complexities of arrangement would be most serious.

On the same Drawing (No. 4) the alternative of *separate* crossings for [illegible] two Gauges is suggested, an arrangement which, from its simplicity, is preferable to that of mixed crossings, but requires more space.

It is to be observed that the switches are by no means the only objectionable parts of a crossing, a junction between two lines of railway, a siding, or any other point where one system of rails necessarily intersects the other. Wherever another rail crosses the rail of the main line, a *gap* necessarily occurs in the main line, in order to allow the flange of a wheel to pass as it goes along the cross line; every such gap inflicts a blow on every wheel that passes over it, and the higher the speed the greater the blow. How much of the wear and tear of stock arises from this source, it is perhaps impossible to ascertain with precision; but it is notorious that the wear and tear of a most important part of the machinery of a railway is mainly due to it—that of the wheels and axles. An injury thus sustained may not cause an accident, as the wheel passes over the spot where the blow is inflicted, but may yet lead to one at another place, the cause of which cannot then be determined. The bending, or partial fracture of an axle sets the wheel out of Gauge, and prepares for greater straining at the next point where the main line is intersected, and thus, by a succession of blows, breakage ensues, or even without breakage the carriage is thrown off the line.

Again, the liability to run off is greatest at these places of intersection or gaps in the main rails.

From the subjoined record (Appendix I. A) of the accidents which have occurred on the Midland Railway during the last twelve months, kept by Mr. Barlow, the resident engineer, it appears that on that line, seven-eighths of the whole number of accidents of a most dangerous class (namely, those resulting from trains getting off the rails) have arisen at places where the continuity of the rail has been interrupted by switches or crossing points. To increase the number of such gaps is, therefore, to add proportionably to what experience has shewn to be the most frequent cause of accident of the most serious class.

In Appendix I. the results of my examination of Mr. Brunel's diagrams are collected into a tabular form, shewing the increased number of such gaps in the continuity of the main lines of rail, and of fixed points to be met by the trains, in stations, at junctions, and at sidings, by the introduction of one additional rail, and by that of two additional rails.

The description of switch referred to in this Table, is the single switch shewn in Fig. 1, Drawing A.

This description of switch has been in most cases discarded, in consequence of the disadvantages pointed out in Fig. 3, Drawing A. It is assumed in these remarks, as the switch adopted for the Mixed Gauge, because it is that form suggested by Mr. Brunel as the most applicable.

With regard to the advantages claimed by Mr. Brunel as attending the use of this switch under certain circumstances, it is only necessary to state that these advantages, such as they are, are purchased by the adoption of an inferior form of switch, involving an additional gap and fixed point in the common main rails. (See Fig. 3, Drawing A.)

Referring to the Table of particulars (Appendix I.), it is only necessary here to state generally, that,

In the case suggested in Drawing No. 1 (of Mr. Brunel):—

There will be two additional half switches, two additional crossing points, two additional pairs of over crossing points, four additional gaps, and three additional meeting points, to be passed over by the trains of either one Gauge or the other, or by both.

In the case of Drawing No. 2 (of Mr. Brunel):—

There will be switches at four different places instead of at two, as with the Single Gauge, and there will be two additional crossing points, two additional pairs of over crossing points, six additional gaps, and four additional meeting points, to be passed over by trains of either one Gauge or the other, or by both.

In the case of Drawing No. 4 (of Mr. Brunel):—

There will be two automaton switches, of a novel and unsafe construction (see Drawing 4A), to be passed over by every train using the crossings, one of these switches being placed the wrong way so as to meet all the trains in one direction. There will also be two additional half switches, four additional crossing points, two additional pairs of over crossing points, six additional gaps, and four additional meeting points, to be passed over by trains of either the one Gauge or the other, or by both.

In the case of Drawing No. 5 (of Mr. Brunel):—

There will be two automaton switches, as in Drawing No. 4, to be passed over by every train using the crossing, one of these switches being placed so as to meet all the trains in one direction; there will also be five additional crossing points, four additional pairs of over crossing points, nine additional gaps, and four additional meeting points.

In the case of Drawing No. 6 (of Mr. Brunel):—

There will be switches at four different places instead of at two, as with the Single Gauge; there will also be six additional crossing points, four additional pairs of over crossing points, twelve additional gaps, and eight additional meeting points, to be passed over by trains of either one Gauge or the other, or by both.

All these additional points of danger, arising from additional intersections of the rails (with the exception of the automaton switches in Drawings 4 and 5), occur on the main lines of rails; so that an accident arising at one of these points would affect the traffic elsewhere, and delay and embarrass, in all probability, other trains than that to which the accident occurred.

The three-rail system thus increases the interruptions or gaps in the main lines of rails, and the still more objectionable meeting points, in the proportion of about two to one, and the four-rail system about as three to one. But if we compare the results of the record of accidents on the Midland Line with the table of additional intersections, and take into account the necessary increase in the number of trains attending the use of a Mixed Gauge, referred to hereafter in these remarks under the head "Traffic Arrangements," I consider that the three-rail system would increase the danger in the proportion of at least four to one, and the four-rail system as five to one, from that cause which has been proved by experience to produce seven-eighths of the railway accidents consequent upon engines or carriages running off the line.

It is further to be considered that the more closely these interruptions of the main line occur, the more difficult it will be to keep the line in good working order, and this far beyond the direct proportion of the number of such interruptions.

From Drawing No. 9 (showing a junction laid with two rails, with three, and with four) it will appear that, as the number of crossing points increase, the main line rail becomes cut up into shorter lengths, and the shorter the length of rail, whether of Mr. Brunel's bridge-rail on longitudinal timbers, or of the double T rail on cross sleepers, the more difficult it necessarily becomes to fix and maintain it.

From the same Drawing (No. 9), and from the other Drawings, it also appears, that the check-rails, at present used as palliatives of danger, become more difficult to apply just as the danger or the necessity for such check rails increases; there being in some cases no room at all for them; as, for instance, in such complications as arise in some portions of Slough Station, and at over-crossing points generally.

In the Mixed Gauge system, therefore, we are partially deprived of a palliative, which is deemed essential to safety under the Single Gauge system, although we need it more than under the ordinary system.

The danger encountered by a fast-train passing through a station without stopping, will, from these causes, be greatly aggravated.

From the whole of the preceding considerations, the following general conclusions, in reference to the effect of the Mixed Gauge system on the permanent way, are drawn,—

First. That the four-rail system increases the complication so much as to be inadmissible, except where absolutely necessary, as at turnplates, &c.

Secondly. That notwithstanding the exercise of the utmost care in construction and maintenance of way, the mixture of Gauges, either by means of three or four rails, introduces in the road itself a greatly increased risk of accident, entirely incapable of remedy, and scarcely justifiable by any considerations of mere convenience.

Arrangement of Stations.

In considering, in the next place, the arrangements of Stations, which will be necessary on a railway of Mixed Gauge, the question of mixed or separate sidings and crossings must be considered more fully than is done in Mr. Brunel's report.

It may be stated at the outset that the separate system will require separate switches at separate places, instead of the connected half-switches added by the mixed system, while it will also introduce an increased number of crossing points; but the separate plan will render them more simple and more easy to lay with proper checks, and to keep in repair.

The idea of arranging Broad and Narrow Gauge stock promiscuously together, suggests immediately great inconvenience.

As regards spare stock, the separate system of arrangement is on the face of it the more convenient, because, whenever an extra vehicle of any kind is wanted, its Gauge being an essential part of the demand, less shifting of the stock will necessarily be required if the two classes are kept separate, than if they are placed promiscuously together; labour and time will thus be saved by separating them.

Common sidings for both Gauges could only be used alternately for vehicles of the one Gauge or the other, not for both at one time, but if once such sidings were laid down, there could be no security against their being used for both kinds of stock at the same time: it is therefore necessary clearly to point out the danger which would arise from such a practice.

This danger will be readily appreciated by any one who has stood by and observed a carriage at a station come into contact with another, while a porter stands perfectly secure between the buffers, the carriage bodies being prevented by the projection of the buffers from approaching so close as to crush him.

By reference to Drawing (No. 10), it will be seen that the carriages of the ordinary construction, Narrow and Broad Gauge, when standing together on a common three-rail siding, will not buff together, the buffers missing each other, and coming in contact instead with the opposite carriage-frames. It is unreasonable to expect that a porter shall always, in the hurry of business, be able to consider whether an approaching carriage is Narrow or Broad Gauge, and, consequently, whether he is safe or not if engaged in the siding: at any rate no such danger should be thrust upon him by defective arrangements. To render a three-rail common siding safe, it would then be necessary to alter the buffers of the entire stock of the whole connected system of railways, using such siding, in such way that the Narrow and Broad carriages should buff together; for when once a number of railways are connected into one system, the stock finds its way to every part of the system at one time or other; indeed, it is the very object of the proposed mixture of Gauges, that goods and passengers may proceed to their destination without change of vehicles; Narrow or Broad Gauge vehicles must be everywhere in turn as the traffic demands; and, until all of them are made to buff indiscriminately together, there can be no safety for porters in a three-rail siding. Accidents of this nature occurred from the use of stock not buffing together on the Glasgow and Greenock Railway until the remedy was applied: within a short period several persons were injured, some fatally.

Besides the danger to the men, it is clear that the buffers of every carriage (whenever two of different Gauges come together) striking the cross framing of the other carriage instead of the longitudinal framing or buffer ends, would knock the carriages to pieces; one or two blows of this nature, indeed, would in all probability so shake the framing of a carriage as to make it unsafe.

Again, in the moving about of stock at stations of considerable traffic, engine-power is used with much advantage. In the same Drawing (No. 10), a Narrow and Broad Gauge carriage are shewn coupled, to draw attention to the fact, that in a three-rail siding used promiscuously for both kinds of stock, this economical and necessary power cannot be used without much danger of throwing the vehicles off the rails by the oblique line of traction which results.

Whenever turnplates are required, the three-rail system must be converted into the four-rail system, as the action of a turnplate implies a concentric arrangement.

For these reasons, the application of the three-rail system at stations appears entirely inadmissible.

It may here be remarked, that collisions on a three-rail Mixed Gauge line between trains of different Gauges, would necessarily be even more disastrous in their consequences than under the present system; the blow would be oblique, and would, therefore, tend to twist and double up the train, and so to bring the carriages into a position in which they would be least able to resist the crushing force.

The four-rail system for sidings has already been shewn to involve a greatly increased number of dangerous points of intersections. It would also be inconvenient at the platforms.

The only alternative, then, is to lay separate sidings for the two Gauges, or, in other words, completely to duplicate the station arrangements.

Traffic Arrangements.

I now proceed to consider how far the number of trains required is affected by the mixture of Gauges.

The object of a Mixed Gauge professes to be, to afford to the public the same amount of convenience as they would derive from an uniform system of one Gauge. Under such a system, passengers or goods from Banbury (for instance), either northward to the Narrow Gauge district, or south-westward to Bristol, or other places now on Broad Gauge lines, would be able to proceed, without change of vehicle, by any train of the day which might be most convenient. To retain the same amount of accommodation on a Mixed Gauge line, it is clear that the same number of trains daily would be required of each Gauge, that is to say, the amount of trains collectively would need to be doubled. The stock would therefore be nearly doubled, the amount of labour and expense in despatching the trains would be much increased, the risk of collisions would be fully doubled, and the profit of course would be diminished, as the public accommodation would not be (by the supposition) increased, but would only remain the same as it would be under an uniform Gauge.

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the narrow
; the other the
the O. & W. W.
narrow; the Birm
the middle.

The interest of a Company possessing a Mixed Gauge line would therefore clearly be, to reduce expense by working mainly on one Gauge, choosing whichever might be most in accordance with their general interests, in which case, it is clear, that they would no longer afford the public (as was implied by the proposal of a Mixed Gauge Line) the same advantages which would have been derived from a separate line of that other Gauge, the working of which would inevitably be, for the reasons we have considered, discouraged.

Cost.

Approximate estimates of the expense, arising in various ways from the mixture of Gauge, are appended. By Appendix II. it will be seen that the additional expense arising from laying the Narrow Gauge (with the necessary facilities for working it) on a Broad Gauge Railway, would be about 5,974*l.* per mile, while, by Appendix III., the increased annual expense of maintenance and working, exclusive of interest on additional capital, would be at least 500*l.* per mile per annum. This latter estimate is founded both on my general experience of the expense of working and maintaining railways, and on a return of the actual cost per train per mile on the London and Birmingham Line, where, from the great number of trains, the cost *per train* is low.

If, as is generally done in such cases, we capitalise this annual expenditure of 500*l.*, it will amount (at 4 per cent.) to 12,500*l.*; adding this to 5,974*l.*, the total additional cost of a Mixed Gauge Line would be 18,474*l.* per mile.

For this vast additional outlay, we should get an inferior railway, less safe and less efficient than the ordinary form of railway.

Looking at the question of cost in another light, and having regard to the fact that one principal reason for the establishment of the Narrow Gauge on the Oxford and Rugby Line, was the accommodation of the coal traffic of the north; this extra annual expense of 500*l.* per mile for working would, if saved, be sufficient for the carriage of 120,000 tons of coal per annum over the whole length of the railway free of all charge, or adding 4 per cent. interest on the original outlay of 5,974*l.* for the carriage of 177,360 tons.*

---

* Over the whole railway, allowing a penny per ton per mile for the expense of carriage.

Or, applying the result to passengers, the whole average number of railway passengers travelling per mile per annum is about 180,000; a Railway Company might therefore take off 1*d.* per mile from all its passengers' fares, for the same annual sum as the laying and working the additional Gauge would amount to.

I have in the foregoing remarks endeavoured fairly to appreciate, and, as far as possible, to point out the means of obviating, by the separation of the stations and traffic, the difficulties both of original construction, of maintenance, and of working, arising from the mixture of Gauges, as well as to estimate the probable additional expense of the system.

What, then, are the advantages to result from its adoption?

By a Narrow Gauge Line from Rugby through Oxford to Reading and Basingstoke, the through traffic from the Narrow Gauge districts in the north and north-east will be carried without interruption to the south, south-west, and south-east, and the communication of the agricultural counties, through which the Oxford and Rugby Line passes, with the coal-fields of Leicestershire will be effected.

On the other hand, the only ostensible object of the Broad Gauge on the line between Oxford and Rugby, is the connexion of Exeter, Bristol, and the agricultural districts passed through by the Great Western Railway, with the towns of Banbury and Rugby, and with the district (also agricultural) between Oxford and Rugby, and this local object, we have seen, can only be purchased at a great cost and by a sacrifice of safety.

In the case of the Oxford, Worcester, and Wolverhampton Line, a main design of which is to afford accommodation to the owners of mineral property in conveying their heavy produce to the works of their customers, the increased cost of the Mixed Gauge arrangements will to a great extent, if not entirely, defeat the local object which it is proposed to effect.

Stock for both Gauges will have to be furnished and maintained; extra lines for the connection of the works with the railway to be laid down, and extra space for the carrying on of the traffic to be provided; this, where the cost of carriage forms a large part of the price of the article when delivered to the consumer, will clearly be a heavy tax on the producer, if it does not, indeed, in many cases, amount to an absolute prohibition of railway conveyance.

It is important to observe, that the termini of this Mixed Gauge system, introduced to remedy the evils of the Break of Gauge, become themselves again the sites of other Breaks of Gauge, at one or other of which all through traffic from a Narrow Gauge to a Broad Gauge district, or *vice versâ*, must be transferred. Thus, by the Mixed Gauge system, the evils hitherto confined to one district will be repeated in new and distant parts of the country.

The Break of Gauge, in short, cannot be remedied by the mixture of Gauges, until such mixture becomes co-extensive with railways themselves, and thus, after enormous expense, we should arrive at last at uniformity, but without the simplicity of construction and arrangement which can alone insure the economy, safety, and efficiency of the railway system.

I am,
Dear Sir,
Yours truly,
(Signed) ROBERT STEPHENSON.

APPENDIX.

APPENDIX I.

TABLE SHOWING COMPLICATIONS ARISING FROM MIXED GAUGE.

	Switches.			Half-Switches.			Automaton Switches.			Crossing Points.			Pairs of Over-Crossing Points.			On Main Line.									
																Gaps.					Meeting Points.				
	II	III	IV	II	III	IV	II	III	IV	II	III	IV	II	III	IV	II	III		IV		II	III		IV	
																	B.	N.	B.	N.		B.	N.	B.	N.
Mr. Brunel's Diagram No. 1, "Siding for both Gauges" ...... Drawing 1	2	2			2					2	4			2		4	6	8			2	3	5		
Mr. Brunel's Diagram No. 2, "Sidings for Narrow and Broad Gauges separately" .... Drawing 2	2	4								2	4			2		4	8	10			2	4	6		
Mr. Brunel's Diagram No. 4, "Crossing" .... Drawing 4	2	2			2			2		2	6			2		4	8	4				4			
Crossings for two Gauges laid separately .... Drawing 4		4									8			2			8	6				2			
Ditto ditto laid together on IV Rail system ...... Drawing 4			4									8			4				8	8				2	2
Mr. Brunel's Diagram No. 5, "Crossing with Siding for both Gauges" Drawing 5	2	2			2			2		4	9		2	6		8	12	12			3	5	5		
Mr. Brunel's Diagram No. 6, "Sidings for Narrow and Broad Gauges separately on IV Rail system" Drawing 6	2		4							2		8			4	4			8	8	2			5	5
Slough Station .... " 7	16	16	32		16			13		27	67	120	12	47	88	28	46	42	56	56	10	24	20	28	28
Coventry Station .... " 8	17	17	34		17			11		17	36	68		17	34	20	32	36	40	40	8	16	20	22	22
A Junction .... " 9	2	2	4		2					4	9	16	2	6	12	8	12	12	16	16	5	8	8	11	11

REMARKS.

The Roman Numerals distinguish the Single Gauge system of II Rails, and the Mixed Gauge systems of III Rails and IV Rails.

The letters B. and N. distinguish the Broad and Narrow Gauge Lines.

In Mr. Brunel's Diagrams Nos. 2 and 6, although he supplies *two* sidings, being of different Gauges they afford only the same description of accommodation as *one* on a Single Gauge Line. The points, &c. required are, therefore, compared with those of one siding, Single Gauge.

By reference to Column "Pairs of Over-Crossing Points," it will be seen that this kind of points is very disproportionately increased by the introduction of rails of a second Gauge, on either the III or IV Rail system.

From this Table it appears that the III Rail Mixed Gauge system about doubles the amount of obstructions on the Main Line from gaps and meeting points. But, as it is shown (Observations, p. 15) that the number of trains on the Mixed Gauge must be doubled, in order to convey the same amount of traffic with equal convenience to the public as a Single Gauge Line under an uniform system, it appears that, even using the III Rail system as the simplest, the mixing of Gauge at least quadruples the amount of obstructions arising from gaps and meeting points on the main line of rails; and to the same extent, *at least*, increases the danger of accidents from this source, to which (see Observations, p. 10) seven-eighths of the accidents resulting from engines and carriages getting off the rails are to be attributed.

APPENDIX I.A.

MIDLAND RAILWAY.

Length of Railway about 300 miles.

Record of Accidents from Engines or Trains getting off the Line, from April 1846 *to April* 1847, *attributable to Switches or Crossing Points.*

DATE.		NATURE OF ACCIDENT.	REMARKS.
1845.			
April	18	Engine off Rails at Points, Derby yard, North end.	
	18	Do. do. South end.	
	27	Shunting at Coke siding, near Eckington.	Mounted *crossing.*
	27	Waggons (3) off a crossing, Kingsbury.	Goods' train shunting for passenger train.
May	3	Engine (Goods) shunting into siding, leading to large turn-table (Masbro').	
	19	Pilot engine off at points, leading to Park-gate branch.	
	19	Engine at points leading to engine-shed, Normanton.	Heel chain broken.
June	5	8 Waggons shunting into goods sidings, Birmingham.	
	17	Engine ditto, near Park-gate works, Masbro'.	Two chairs had been fixed on the line, one of them in the opening between the switch and the rail.
Aug.	5	Engine coming out of M. C. engine-shed on to Derwent-bridge.	Mounted at crossing, curve sharp, engines coupled too tight to tenders.
July	3	Ditto at North Junction, Derby.	Points wrong, pointsman absent from his points.
Aug.	25	Ditto at points leading to engine-shed, Derby.	
	29	Waggons at sidings, Birmingham end.	
Sept.	4	Tender at first crossing, north branch.	Plate layers had been laying in a wing rail, and left it too tight.
	17	Engine at points near coal-yard, Sheffield.	
	17	Ditto at points (locality not stated).	Cotter left out of lever rod.
	30	Do. shunting to the turn-table, Nottingham.	

MIDLAND RAILWAY.—*Record of Accidents continued.*

DATE.	NATURE OF ACCIDENT.	REMARKS.
1845.		
Oct. 5	Engine coming out of engine-shed, Derby.	Broken chair.
5	Ditto mounted crossing.	Engine too tight coupled.
19	Ditto at points at Park-gate works, Sheffield and Rotherham.	
Nov. 5	Ditto at Points, Nottingham.	No person holding points.
12	Tender mounted crossing coming out of M. C. shed.	Curve very sharp.
Dec. 15	Engine at crossing west end of Derwent-bridge.	Engine too tight in Gauge.
1847. Jan.	Engine near ticket platform, Birmingham.	
7	Engine and break at facing points, Sheffield tunnel.	Break in front of engine; guard's leg broken.
7	Engine mounted crossing M. C. engine-shed, Derby.	Curve too sharp.
7	Tender at points, North Junction.	Shunting without any one holding points.
7	Engine at crossing in Cheltenham Station.	
7	2 Waggons facing points, Camp-hill.	Cotter shaken out of connecting-rod.
31	Passenger engine ran into goods siding at Gloucester.	Supposed from points having been purposely fastened.
Feb. 8	Engine at crossing, Derwent-bridge.	Check-rail not tight enough.
17	Ditto mounted at crossing, Belper, while shunting.	Curves sharp and engine coupled tight.
March 5	Mail engine off at points, Clay Cross.	Platelayers in changing points had left them unfinished at night and keyed up. A goods train having occasion to shunt, the guard removed the key, and omitted to replace it.
5	Leeds and Bradford goods engine at points, Leeds.	Broken tie-rods.
6	Engine at north end, Derby-yard.	
6	Waggons at Moseley ballast siding.	
30	Engine shunting to coke-shed, Derby.	

Total number of Accidents attributable to Switches, or Crossing Points 39
Attributable to Switches 21
„ to Crossing Points 17
Occurring at one end or the other, (which, not capable of being ascertained) 1
Total 39

Record of Accidents not attributable to Switches or Crossing Points.

DATE.	NATURE OF ACCIDENT.	REMARKS.
1846.		
Aug. 5	Engine at Oakenshaw.	A rail taken out in repairing line: engine-driver neglected to observe the signals.
Dec. 26	Waggons at Badgeworth Embankment, near Gloucester.	Road in good order: supposed to have arisen from a waggon out of gauge.
1847.		
Feb. 8	Pilot Engine, near Cheltenham.	Ganger had opened out too great a length of baulk-road.
24	Engine on curve, 10 chains radius, near Derby.	A joint-chair left unfinished.
Mar. 20	22 Waggons, near Masborough.	Plate-layers relaying had left a loose key.

Total number of Accidents not attributable to switches or crossings . . 5

The total number of Accidents from engines and trains getting off the line during the year was therefore 44

39, *or seven-eighths, of which were directly attributable to switches or crossing points.*

APPENDIX II.

Estimate of the expense of adapting a Broad Gauge Railway to a Narrow Gauge Traffic in addition to Broad Gauge Traffic. Under the Three Rail arrangement suggested by Mr. Brunel.

EXPENSE PER MILE ADDITIONAL.

Permanent way		£2,695 0 0
M. Brunel's estimate given at page 367 of the Appendix, to Report of Gauge Commissioners is—		
(The rails being taken at 10*l.* per ton)	£2,500 0 0	
To this must be added for additional ballast admittedly omitted by Mr. Brunel, per mile	195 0 0	
	£2,695 0 0	
Sidings, derived from the actual cost on the London and Birmingham Railway, per mile		150 0 0
Points and Crossings, derived from the actual cost on the London and Birmingham Railway, per mile		194 0 0
Passenger Stations, allowing nothing for additional platforms or offices, a very moderate additional shed-room at Road Stations, only 1800*l.* additional for shedding at each terminal station, and nothing additional for land		172 0 0
Goods Stations		688 0 0
For very moderate accommodation, if the stock is to be kept separate, as shown to be necessary from considerations of safety and convenience in remarks (page 13)		
Plant. Taking only *half* of the actual cost of the plant per mile on the London and North-Western Railway, and allowing one engine and tender for every two miles		2,075 0 0
Additional per mile of double way		£5,974 0 0

APPENDIX III.

Additional annual cost of working a Mixed Gauge Line. Expense per Train per Mile on the London and Birmingham Railway.

The following Table shews the expense of Passenger Trains. That of Goods Trains is greater by 8*d.* per train per mile.

	Actual Expense on the London and Birmingham Railway.		Proportion chargeable on Trains upon the Additional Gauge.	
	s.	*d.*	*s.*	*d.*
Maintenance of Way	0	5¼	0	2
Locomotive Power	1	0	0	11
Police	0	2	0	0½
Coaching and Merchandise	0	7¾	0	3½
Coach and Waggon Repairs	0	2½	0	2
Depreciation of Stock	0	4	0	3
Mileage Duty	0	5½	—	
Rates and Taxes	0	3	—	
General Charges	0	2	—	
Total	3	8	1	10

Nine additional Trains per day each way, for 312 working days, would amount to 9 × 2 × 1*s.* 10*d.* × 312 = 514*l.* 16*s.* per mile per annum additional.

Say 500*l.* per mile additional.

The average expense of working thirty-six Passenger Railways per mile (according to Mr. Laing's Statistics of British Railways, page 14), was about 1400*l.* per annum.

The additional expense of working a Mixed Gauge Railway, as compared with a Single Gauge Railway, is thus taken at something more than one-third of the whole expense of working a Single Gauge Railway.

MR. BRUNEL'S REPORT ON THE DOUBLE GAUGE, TO WHICH THE FOREGOING OBSERVATIONS OF MR. R. STEPHENSON APPLY.

To the Directors of the Great Western Railway Company.

18, Duke-Street, Westminster,
16th January 1847.

Gentlemen,

I have deferred reporting to you upon the mode in which I should recommend to introduce the Narrow Gauge upon the Oxford and Rugby Railway, because, as the time was not yet arrived for laying the rails, it was not absolutely necessary; and as whatever mode I might recommend would, as a matter of course, become the subject of criticism by those who resist the mixture of Gauges as affecting the question of the use of the Broad Gauge, I did not wish at an earlier period than necessary to give this new occasion for introducing into any question that might come under discussion, either before the public or before Parliament, any part of the old and vexatious questions of Gauge. As, however, it is desired by the Board of Trade that some particular plan should now be determined upon, I beg to say that my present intention is to recommend on the Rugby Line a single additional rail to each line of rails or separate railway, and that the outer rail of each railway should be common to the two Gauges in the manner shown in the accompanying plan.

This is the simplest mode of uniting the Gauges, and, if it be so desired, admits, without any complication whatever, of the running of all the trains of both Gauges into the same sidings, and up to the same passenger platforms, and, if the switches be coupled or connected exactly, as if no diversity of Gauge existed. This will be apparent by the accompanying plan, No. 1, while at the same time an advantage may actually be derived from the Double Gauge, which may be made the means of keeping two classes of traffic totally distinct, if such be desired, without the possibility of the trains belonging to the one running into the sidings used by the other when one train has to pass the other, an arrangement which would be particularly applicable to the Rugby Line, if, as has been assumed by the advocates for laying the Narrow Gauge on this line, a large through coal trade is to come upon it from the northern Narrow Gauge lines.

Thus, as shewn on Plan No. 2, a siding may be made into which the Narrow Gauge trains would run, and the switch for which could not affect the Broad Gauge trains, which could therefore run past at full speed without having any switches to attend to; and the Narrow Gauge lines might be carried in like manner past any siding intended solely for the quick Broad Gauge trains, as shewn in the same figure.

Crossings from one line to the other are, at least on the Great Western lines, of rare occurrence and but little used, and on the Great Western Railway they are always kept locked, and used only in case of accident on the stoppage of one line. They are upon all railways placed leading backwards, so that they cannot, even if the switches be wrong, affect the running trains, and are only used at very low speeds. If, therefore, there were any such complication as has been alleged, it would be quite unimportant; but the annexed plan, No. 4, shews that they may be perfectly simple, and as easily worked when they may occasionally be required as with the Single Gauge. By this arrangement there is only one switch and point on each main line, but even that, as has been before stated, being placed in the direction of, and not meeting the running train, may be disregarded. The other switch is not on the main line, and, moreover, would be self-acting, and being moved by an opposite check rail, would open and shut of itself according to the gauge of the wheels running past it. Such a crossing, therefore, would be as nearly as possible as simple in respect of each Gauge as an ordinary crossing.

In Fig. 5. is shown a crossing, such as we prefer them on the Great Western Railway, combined with the siding or lay-by. As it is seldom that the emergency arises for using a crossing, without at the same time rendering a siding a useful aid in this arrangement, the crossing may be made either common to the two, or the advantage of separating two classes of traffic may be obtained, as before, by working the traffic on different Gauges, and keeping the crossing as well as the sidings distinct. See Fig. 5.

Although I have recommended as a general principle, on the Rugby Line, the adoption of a third rail only, and the making the outer rail the one common to the two, yet there may be parts of the line where I should prefer two additional rails, making a distinct Narrow Gauge within the Wide, as shown in Fig. 6.

With respect to the mode of laying the rails, either longitudinal timbers, as on the Great Western Railway, or transverse sleepers, as on the London and Birmingham Railway, may be used. In either case, the mode of laying is not affected by this circumstance of the additional rail or rails. Either three or four longitudinal timbers, each with its rail, may be framed together just as two are now, or as three or four or even more now are at crossings or in stations, or three or four chairs may be bolted on one sleeper. It is in this latter mode that I have arranged with Mr. Barlow, the engineer of the Midland Railway

Company, to lay the Mixed Gauge which was originally provided for by Parliament between Cheltenham and Gloucester; but where I should be uninfluenced by the desire to meet the view of others, I should give the preference to longitudinal timbers.

I am, Gentlemen,
Your obedient Servant,
(Signed) I. K. Brunel.

To the Directors of the
Great Western Railway Company.

Letter from the Commissioners of Railway to the Directors of the London and North Western Railway Company, enclosing a Copy of Mr. Brunel's Report on the Double Gauge.

Office of Commissioners of Railways,
29, *Great George Street*, 15*th April* 1847.

Sir,

I am directed by the Commissioners of Railways to transmit to you for the information of the Directors of the London and North-Western Railway Company a copy of the Report and Plan furnished by the Great Western Railway Company, of the method proposed by them for laying down the Narrow in conjunction with the Broad Gauge upon the Oxford and Rugby line, and to inform you at the same time, that a model of the proposed method has been deposited in this office, and it is open for the inspection of the Directors, or any person they may wish to send for that purpose.

The Commissioners, at the same time, request that any observations the Directors may have to make upon the proposed plan, may be communicated in writing for their consideration.

I have the honour to be,
Sir,
Your most obedient Servant,
Frederick W. A. Bruce.

To the Secretary of the
London and North-Western Railway Company.

THE DOUBLE GAUGE.

LIST OF DRAWINGS ACCOMPANYING MR. STEPHENSON'S OBSERVATIONS ON MR. BRUNEL'S REPORT.

Exact copies of the Diagrams which accompanied Mr. Brunel's report are given in these Drawings.

In these Diagrams, being merely sketches, the gaps in the rails, the fixed points, and other important details connected with the intersections of the rails under the Double Gauge system, are omitted.

Under each of Mr. Brunel's Diagrams, therefore, a detailed drawing on the same scale is added in which these omissions are supplied.

In order to prevent confusion in the references to the Drawings, the figures (distinguishing the Diagrams) adopted in Mr. Brunel's report are preserved.

Drawing A.—Explanatory of terms used in the observations.

„ 1-2.—Mr. Brunel's sketch of a siding for both Gauges conjointly.
The same, with the more important details inserted.
Mr. Brunel's sketch of separate sidings for Broad and Narrow Gauge lines.
The same, with the more important details inserted.

„ 4.—Mr. Brunel's sketch of a crossing for both Gauges conjointly.
The same, with the more important details inserted.

„ 4A.—Drawing of an automaton switch.

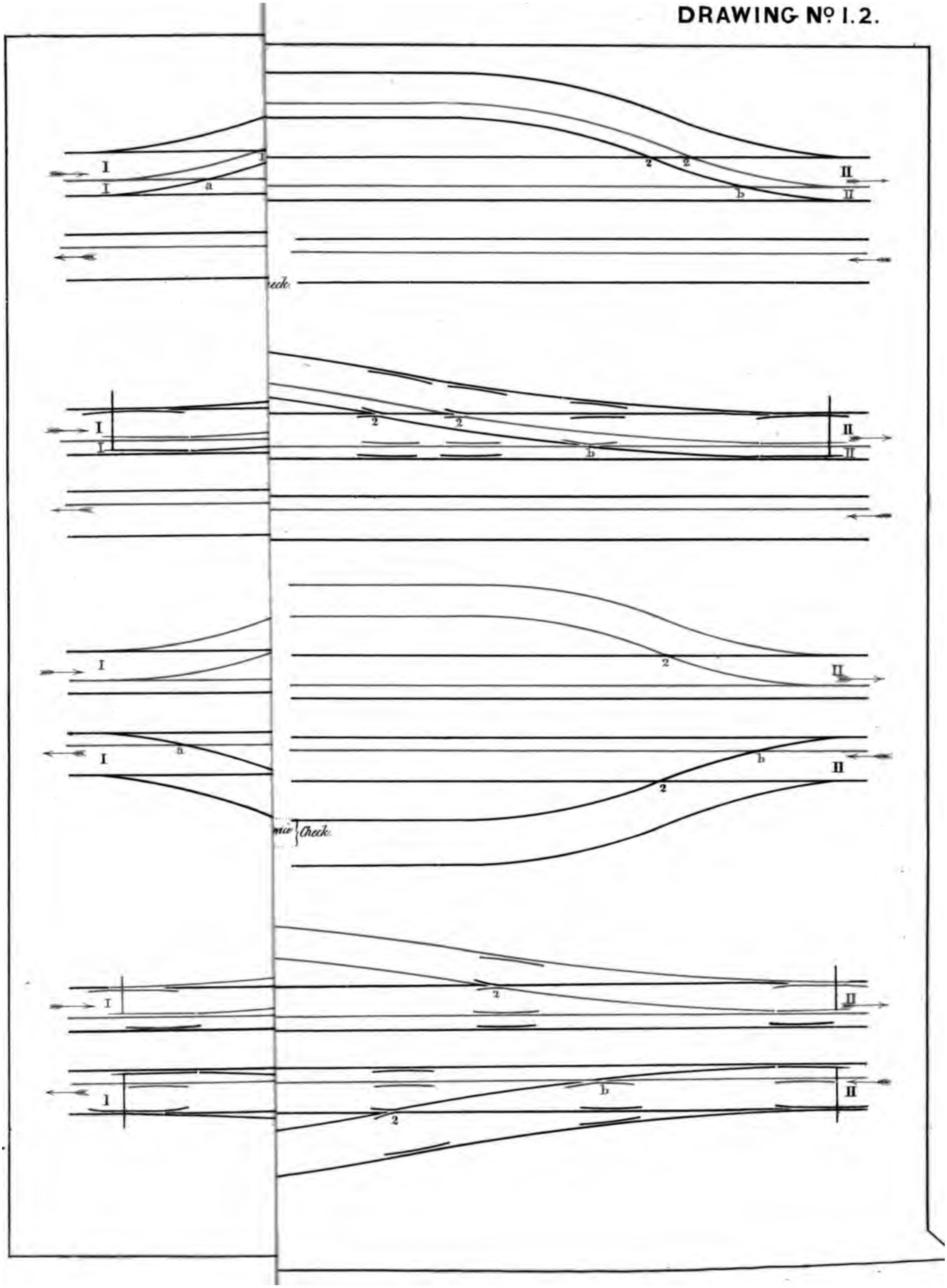
„ 5-6.—Mr. Brunel's sketch of a crossing, together with a siding for both Gauges conjointly.
The same, with the more important details inserted.
Mr. Brunel's sketch of separate sidings for Broad and Narrow Gauge lines.
The same, with the more important details inserted.

„ 7-8.—Rough plans of Slough and Coventry stations, the roads being laid.
As at present.
Under the three-rail Mixed Gauge system, and
Under the four-rail Mixed Gauge system.
[These Drawings, in consequence of their size and complexity, have not been lithographed.]

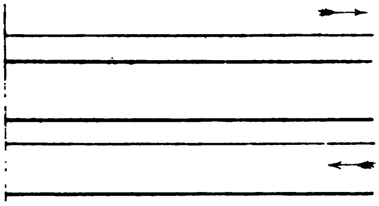
„ 9.—Comparative plans of a junction between a railway and a branch railway.
As at present laid.
Under the three-rail Mixed Gauge system, and
Under the four-rail Mixed Gauge system.

„ 10.—Drawing of a Broad and Narrow Gauge carriage, on a three-rail siding, as proposed by Mr. Brunel, shewing how they will be circumstanced as to buffing and drawing together.

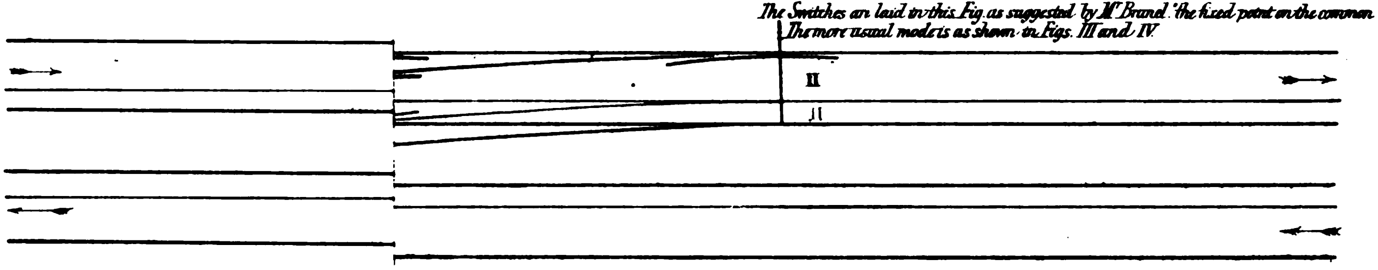
DRAWING Nº 1.2.



DRAWING No. 4.



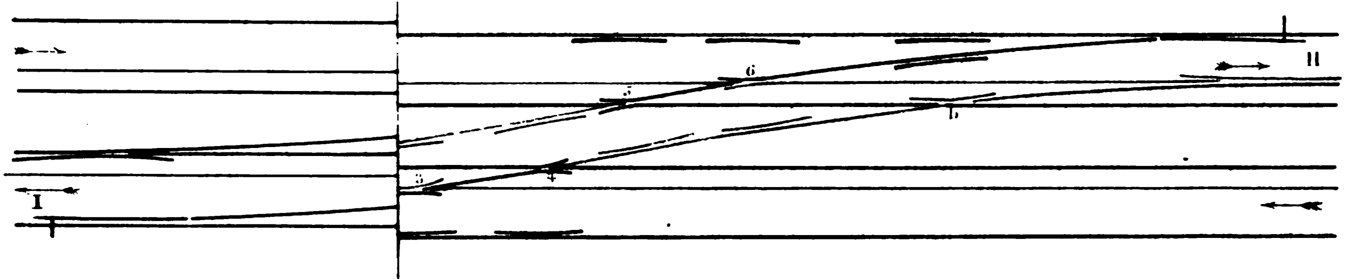
The Switches are laid in this Fig. as suggested by Mr Brunel. "the fixed point on the common line."
The more usual mode is as shown in Figs. III and IV.

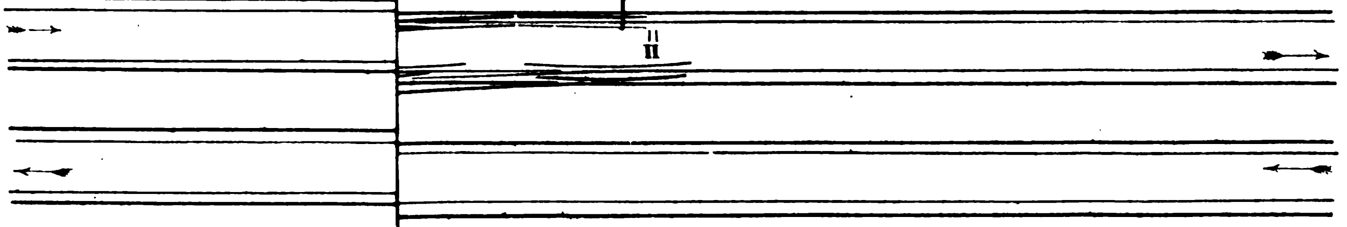


An ordinary Crossing for
2 Switches I.II: 2 Cross
A Crossing for Two Gauges
2 Switches I.II 2 Half
Crossings for Two Gauges U
4 Switches I II; I.II; 8
Crossings for Two Gauges
4 Switches I II; I.II. 8

e Automaton Switches in a Crossing. To do so the Crossing is made in Fig 2. 200 Feet long:
ecome unusually sharp (1 in 12.) and yet the Automaton Switch Tongue is necessarily
sides at · · two points which are totally inadmissible as they cannot be guarded
eet the Traffic on the Broad Guage Main Line. On the whole a common Half
be preferable to the Automaton in this case; For Details of Automaton Switch

be where there is room, to lay separate Crossings for the Two Gauges as shown in Fig 3.





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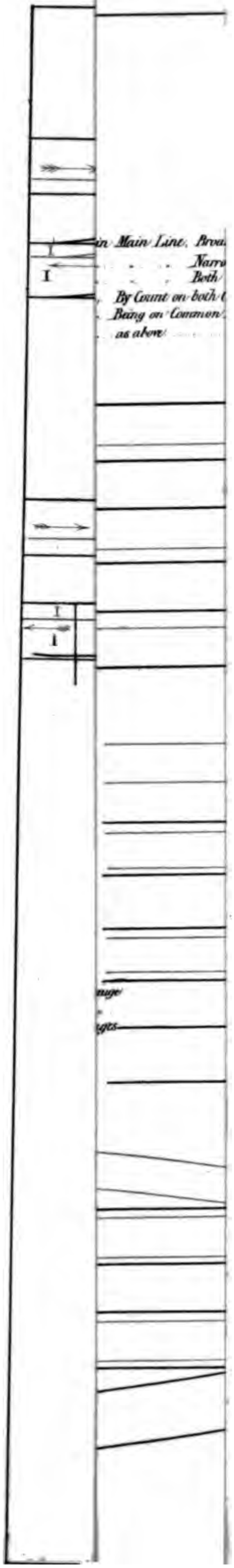
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PLAN OF A JUNCTION.

DRAWING Nº 9.

A Junction laid as in Fig I. for Single Gauge req
2 Switches I·II.; 4 Crossing Points 1 to 4; 2 Pair
D° as in Fig II. for Mixed Gauge on Three Rail syst
2 Switches I·II.; 2 Half Switches I·II; 9 Crossin
D° as in Fig III. for Mixed Gauge on Four Rail s
4 Switches I·II, I·II; 16 Crossing Points 1 to 4,